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tech tips

Servicing Video Comb Filters

Comb filters recover nearly all the video information in an NTSC (National Television Standards Committee) television signai. The comb filter uses phases to separate the color from the luminance signals.

The Benefits Of The Comb Filter

Compared to conventional bandpass filtering, comb filters provide four picture improvements: 1) The luminance signal has higher resolution,

Conventional Video

With Comb Filter

Fig. 1: The biggest impact of a comb filter is the extra video resolution, which make smaller objects in the picture show more clearly.

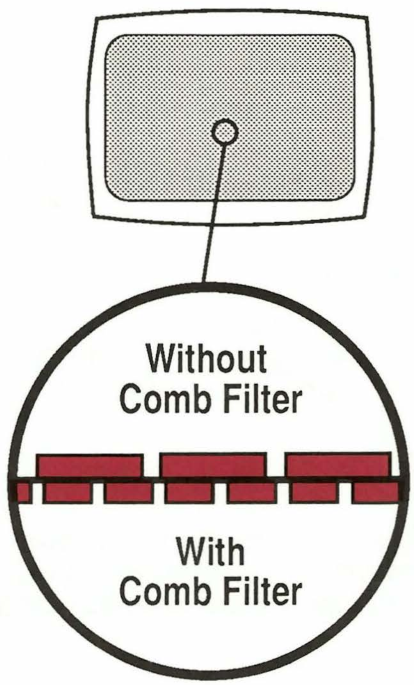

Fig. 2: When combined with a wideband color demodulator, the comb filter allows color detail on objects 42% smaller than a conventional bandpass system.

2). The color signal can have higher resolution if fed to a "wideband I" demodulator, 3) There is less color subcarrier interference in the luminance signal, and 4) Objects with a fine geometric pattern are less likely to cause color rainbowing. Figures 1-4 show examples of each of these conditions.

Figure 1 compares the horizontal resolution of a conventional TV receiver and one with a comb filter. Notice that the increased resolution allows smaller objects to be seen clearly.

Figure 2 is a graphic representation of the smallest object which can appear on the TV screen and still appear in color. A normal TV receiver is limited to resolution of about 0.5 MHz, or objects about 2.5% the width of the TV screen. On a 27" TV screen, this limits color to object about 0.55 inches wide. Smaller objects appear in black and white, even if the camera detects color.

The comb filter, if combined with a color demodulator with full-band "I" demodulation, can show some objects in their proper color when at a luminance frequency of 1.2 MHz. This means

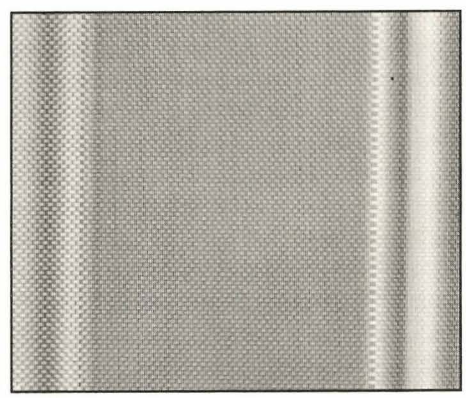

Fig. 3: If any of the 3.58 MHz color subcarrier feeds through the video amplifiers, interference in the form of small dots appear in areas of highly saturated color.

the smallest colored image is 42% smaller than in a conventional receiver.

Figure 3 shows what color subcarrier leakage looks like on a TV receiver. If the 3.579545 MHz (3.58 MHz) subcarrier reaches the CRT through the video amplifiers, it causes a grainy effect. Subcarrier leakage is especially noticeable in picture areas of highly saturated color. It can also cause the edges of graphic characters to develop a "steppy" look. This steppiness depends

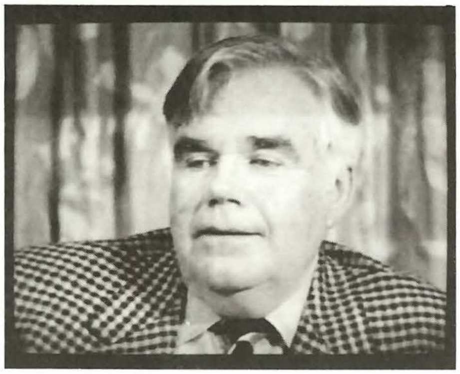

Fig. 4: Comb filters greatly reduce the random color rainbows that appear when a TV scene includes an object with fine pattern, such as a herring bone jacket or tie.

on the combination of foreground and background colors.

Figure 4 shows a pattern that can cause false color rainbowing when the camera is at certain distances. Color appears when the spacing between the objects in the picture repeat at a frequency near 3.58 MHz.

What The Comb Filter Does

The only job of the comb filter is to separate the luminance from the color signals. The comb filter separates the two signals by their phases. This differs from conventional receivers, which separate color from luminance with frequency filters. The main difference in the two methods is that phase separation can correctly separate the signals in the frequency band where the color and luminance signals overlap, as Fig. 5 shows. The details of this "combing" process are covered near the end of this Tech Tip.

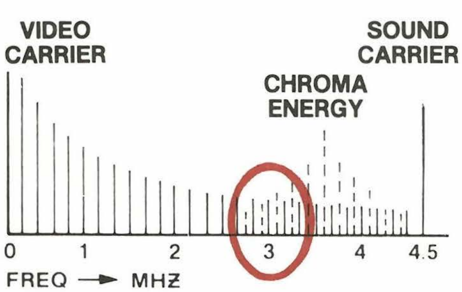

Fig. 5: The comb filter uses phase detection to separate the luminance and chroma signals where they overlap in frequency.

The Symptoms Of A Bad Comb Filter

Comb filter failures cause two types of problems: 1) One or both outputs are missing, or 2) Both outputs produce signals, but the signals are improperly separated. The symptoms differ, depending on the type of failure.

If the chroma output is missing, the receiver usually produces a good black and white picture, with weak or missing color. If the luminance signal is missing, the receiver often produces a blank CRT, since safety or sandcastle circuits may blank the raster when luminance is missing. If the raster is not blanked, there may be broad, blotchy areas of color, without the detail carried by the luminance signal.

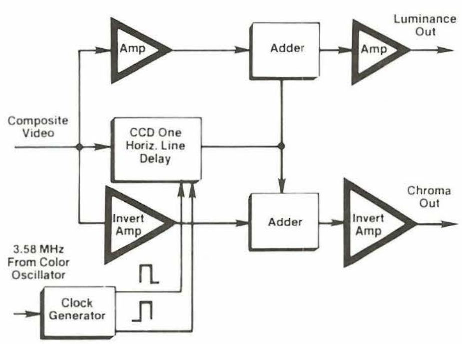

Fig. 6: Some comb filter failures eliminates one of the output signals, while others reduce the ability to separate signals correctly.

Often, both comb filter outputs produce a signal, but a bad part or a change in alignment causes the signals to separate incorrectly. The receiver may appear to work normally, but the picture lacks the extra detail the comb filter makes possible. It works about the same as a conventional receiver.

At other times, the receiver produces a worse picture than a conventional receiver, because there is no 3.58 MHz color trap in the video amplifier. The under-combed luminance may cause excessive subcarrier leakage, and large colored areas show "salt and pepper" effects.

The Sencore VA62A Universal Video Analyzer has several features which help identify comb filter problems. The first features are the special video test patterns, which dynamically test for correct signal separation. The other features simplify testing of bad stages.

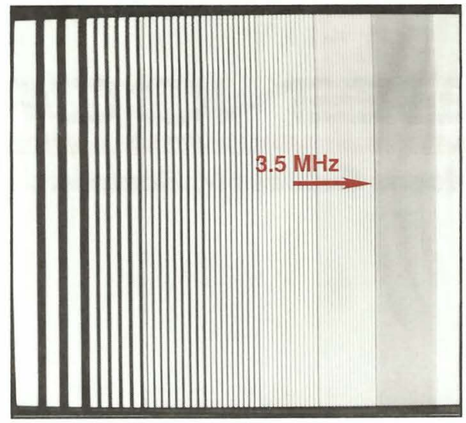

Fig. 7: All of the frequency bars of the Multiburst Bar Sweep, except for the 3.5 MHz bar, are phased as luminance to dynamically test the comb filter.

Use The Correct VA62A Pattern To Identify Problems

Two VA62A patterns dynamically test the comb filter. The Multiburst Bar Sweep tests the luminance separation path, and the Chroma Bar Sweep tests the chroma path.

The Multiburst Bar Sweep has 10 different video bars, each of which represents a different amount of resolution on the screen. All the bars are phased as luminance signals, except the "3.5" bar. This bar (see figure 7) is phased as a color bar, and should be removed from the luminance path by the comb filter.

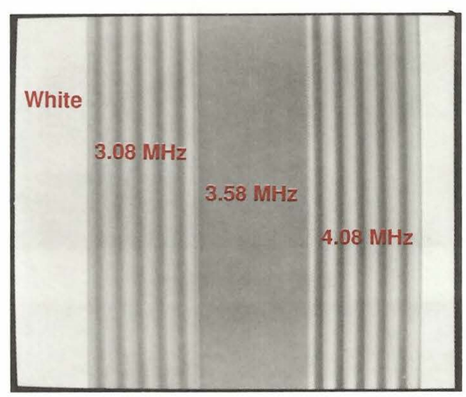

Fig. 8: The Chroma Bar Sweep dynamically tests phase separation and chroma frequency response with three bars phased as color. The outside edges are 100% white luminance information.

The Chroma Bar Sweep has three test bars, all phased as color. The difference between the center bar and the other two is frequency. The bar to the left of center is a chroma signal, 500 kHz lower in frequency than the color subcarrier. The far right-hand bar is 500 kHz higher in frequency than the subcarrier. If all the color circuits are working correctly, all three bars have the same amount of color saturation.

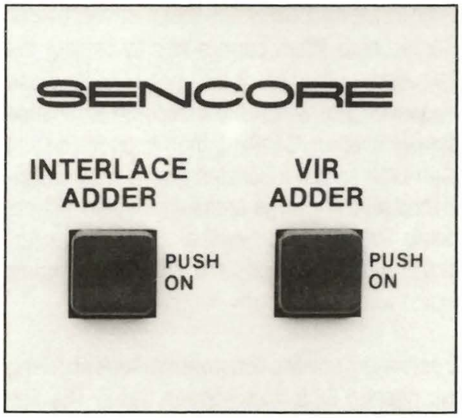

Fig. 9: Leave the "Interlace Adder" button turned off to check for color subcarrier leakage on the receiver picture tube.

If the comb filter works correctly, the center bar will be free from the "salt and pepper" interference caused by the color subcarrier. Depending on the design of the comb filter, the other bars may have a small amount of subcarrier interference, but proper comb filter adjustment keeps the interference at a minimum.

The VA62A's "Interlace Adder" simplifies comb filter testing. Removing interlace sync (setting the "Interlace Adder" button to its "out" position) causes the phase of the color subcarrier to repeat from one vertical sweep to the next, making it much easier to see subcarrier interference. An interlaced signal, as available from TV stations, VCRs, and most video generators, reverses the phase of the color subcarrier on alternating frames of video information, making tests from the TV CRT more difficult. Leave the VA62A's Interlace Adder turned off for comb filter testing.

Aligning The Comb Filter

The most common comb filters, which use glass delay lines, need proper alignment. Adjustable coils and potentiometers set the phase and levels of the signals for correct combing. The VA62A's video patterns let you dynamically set the alignment controls—usually by watching the receiver's CRT.

Use non-interlaced sync, and adjust the comb filter controls for the least amount of subcarrier leakage, which shows as white dots in the center bar. If you have trouble seeing the results on the CRT, connect an oscilloscope or waveform analyzer to the comb filter's luminance output. Adjust the circuits for the smallest amplitude on the center Chroma Bar Sweep bar, or on the 3.5 MHz bar of the Multiburst Bar Sweep.

Use the SC61 Waveform Analyzer's "Delta Peak-to-Peak Volts" function to digitally monitor the bar as you make the circuit adjustment. Follow these steps to make this test:

1. Connect one of the SC61 probes to the comb filter's luminance output.

2. Connect the VA62A, and set it to display the Bar Sweep pattern you like best.

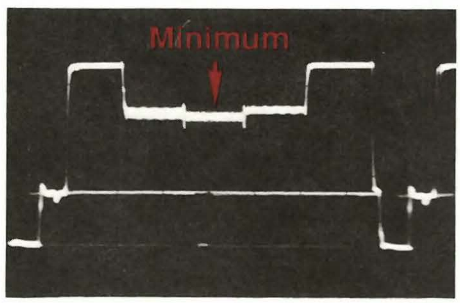

Fig. 10: Set the comb filter for minimum amplitude on the Chroma Bar Sweep pattern. Use the SC61's Delta Peak-to-Peak function to measure its amplitude while ignoring the other parts of the signal.

3. Set the SC61 to display the composite video at the horizontal rate.

(NOTE: Be sure you use one of the SC61's TV trigger functions. Either set to the preset horizontal position at the bottom position of the TIMEBASE FREQ switch, or else set the TRIGGER MODE switch to the "TV" position. Set the TRIGGER POLARITY switch to agree with the polarity of the sync information. Most signals need "negative" sync.)

4. Press the "DELTA PPV" button for the channel you're using.

5. Adjust the "DELTA BEGIN" and "DELTA END" controls until the intensified area just covers the 3.5 MHz bar on the video display.

6. Adjust the comb filter null controls for the smallest reading on the digital display.

Troubleshooting Comb Filters

NOTE: Signal substitution only works if you have a VA62A reference signal connected to the receiver's input, while substituting signals at later stages. Connect the VA62A's RF output to the antenna input, and set both to the same channel. If you're servicing a video monitor with a direct-video input, connect the VA62A's "VCR Standard" output signal to the video input before substiiuting signals.

The comb filter can cause a "blank raster" symptom. Follow these steps to test the comb filter:

1. Connect the VA62A's RF or VCR Standard signal to the input. This references the circuits for positive test results.

2. Set the VA62A's DRIVE SIGNAL switch to the "Video Pattern" position. This produces a composite video substitute signal.

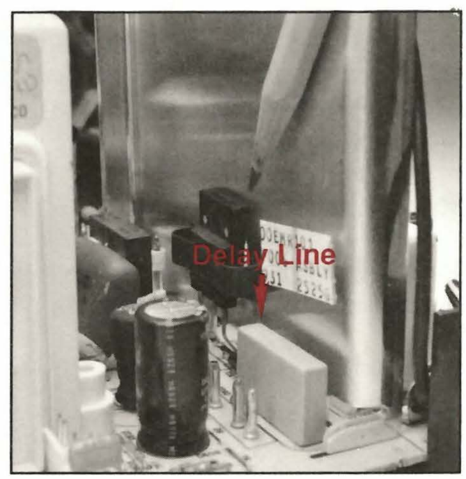

Fig. 11: The large square object is the comb filter delay line. Inject VA62 substitute signals at the output and the input of the comb filter to determine if it's the cause of poor video.

3. Set the DIGITAL METER switch to the "Drive Signal" position. The meter then monitors the true peak-to-peak level of the drive output.

4. Set the DRIVE RANGE and DRIVE LEVEL controls until the VA62A's digital meter shows the same peak-to-peak level as the signal normally found at the comb filter's luminance output. Use "+" or "-" drive, depending on the polarity of the waveform shown on the schematic.

5. Connect the black DRIVE OUTPUT lead to chassis ground, and connect the red lead to the comb filter output.

If there is still no picture, the problem is closer to the output. Locate a test point about half way between the comb filter and the CRT and inject a substitute signal again. Continue injecting signals until you find a stage which produces an improved picture when injecting at its output, and bad results when injecting at its input. That is the defective stage.

If video returns when injecting at the comb filter's output, the video circuits after the comb filter are working. Disconnect the VA62A drive lead and readjust the DRIVE LEVEL controls for the signal level shown at the comb filter's input. Connect to its input. If the picture is bad, the comb filter is at fault. If the picture again returns, the problem is in a stage ahead of the comb filter. Continue injecting signals into earlier stages until you find the bad stage.

When troubleshooting CCD-based comb filters, you may need to combine signal substitution and signal tracing. While injecting the substitute signal with the VA62A, use your SC61 Waveform Analyzer to test the other inputs. Confirm that the amplitude and frequency of the master clock signal, power supply voltages, and support circuits are correct.

How Comb Filters Work

Comb filters depend on phase comparisons to separate luminance from chroma signals. In NTSC color, the phase of the amplitude modulated 3.58 MHz color subcarrier reverses from one horizontal line to the next. Nearly all luminance information has a similar phase between adjacent horizontal lines.

To identify phase, the comb filter delays the composite video and chroma signal by 63.5 microseconds (the time for one horizontal line) and then adds the delayed signal to the non-delayed signal. The phase of the delayed color subcarrier is the opposite of the subcarrier in the non-delayed signal, causing the subcarrier and its modulation sidebands to cancel. The resulting luminance signal, which has the chroma signals "combed" out, feeds the video amplifiers.

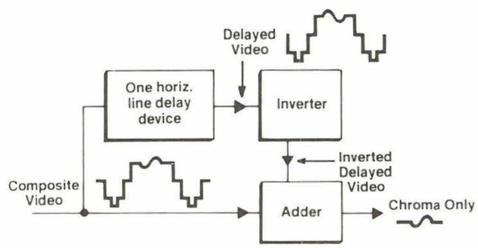

Fig. 12: The comb filter separates the chroma and luminance signals by delaying the video signal for one horizontal line, and then adding it to the non-delayed signal. After cancelling the chroma, the "combed" luminance is inverted and added back to the original signal to recover the chroma.

The chroma information is then recovered from the composite signal by inverting the combed luminance signal and adding it back to the non-delayed signal. The luminance part of the signal cancels, leaving only "combed" chroma to feed to the color circuits.

Comb filter operation assumes there are few changes in the luminance signal from one horizontal line to the next. There are picture conditions which seem to cause a phase reversal between lines in the luminance signal. For example, a bright object in the top of the picture sitting next to a dark object in the bottom of the picture causes a one-line phase reversal where the two meet. The comb filter thinks this is a chroma signal, and removes it from the signal fed to the video amplifiers. This reduces vertical detail.

Some comb filters correct this by limiting the frequency response of the delay line to those frequencies in which the color and luminance signals overlap. Combing then happens only at high luminance frequencies, leaving scene transitions affecting large areas unaffected. Others comb filters add a "vertical detail enhancer" circuit which re-inserts the luminance signals which were accidentally combed out.

Comb filters use two common methods of getting the needed 63.5 microsecond delay. The first method uses a "glass" or "acoustical" delay line based on a piezo-electric crystal. Glass delay lines generally operate over a narrow range of frequencies, so they do not need separate circuits to recover the vertical detail.

The second delaying method uses an integrated circuit called a "charge coupled device" (CCD) or "bucket brigade." These digital delay lines operate over the entire video frequency range, and need circuits to re-insert vertical transitions.

For More Information
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